Gradient winds.—It is of interest to compare the actual directions and speed of the balloons with the theoretical "gradient wind," which is defined as the wind in which equilibrium is maintained between the pull of gravity down the pressure slope, the deflective tendency due to the earth's rotation, and centrifugal tendency due to the curvature of the wind path. The direction of the gradient wind is normal to the pressure gradient or parallel to the isobars. The effect of friction becomes so small at a height of only a few hundred meters that the actual wind above such heights is essentially the same as the gradient wind.

TABLE 1.—*Speeds and altitudes.*[1]

(See Fig. 3.)

Time.	Gradient velocity.	Balloon No. 1. (5,000 feet=1,524 m.).		Balloon No. 2. (10,000 feet=3,048 m.).	
		Speed.	Average altitude.	Speed.	Average altitude.
p. m.	*Meters/sec.*	*Meters/sec.*	*Meters.*	*Meters/sec.*	*Meters.*
11 to 12		13.4	1,371	23.2	2,591
a. m.					
12 to 1		19.7	1,554	21.5	3,048
1 to 2	14.8 (?)	13.4	1,580	19.2	3,048
2 to 3		14.3	1,570	14.8	3,048
3 to 4		12.5	1,585	12.5	3,017
4 to 5		12.5	1,575	17.0	3,050
5 to 6		14.3	1,493	17.0	3,050
6 to 7		15.2	1,220	22.8	2,895
7 to 8	11.5	10.3	1,828	16.1	3,078
8 to 9		8.9	2,073	21.0	3,505
9 to 10		20.6	1,371	29.3	3,566
10 to 11		26.8	1,402	22.4	3,658
11 to 12		3.6	1,158	17.0	3,353
p. m.					
12 to 1	....	11.6	2,438	8.0	3,353
1 to 2	....	6.7	3,353	....	....

[1] The English units which were used in the early portions of this paper were the units in which the data were actually obtained—from barographs, thermometers, etc. However, in the discussion of the data, it is more convenient to employ the metric units, and these have been used in the table and in the following discussion.

Table 1 and figure 3 show the distances actually covered by each balloon, taken from figure 2, and the average altitude during each hour. The computed gradient wind is shown in the second column. It is computed from the isobars at 1 a. m. and 7 a. m.

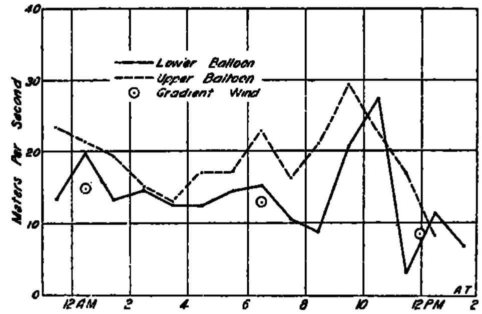

FIG. 3.—Speeds of the balloons.

It will be noted that the agreement during the night between the computed and the observed wind speed at the lower level is quite good. The average speed between 11 p. m. and 5 a. m. is 14.3 meters per second for the lower balloon, within 0.5 meters per second of the computed speed from the 1 a. m. map.

As was pointed out above, the altitudes, and the speeds at various altitudes, were so variable during the later hours of the trip that very little can be done by way of comparison. The computed winds given in the table are for latitudes 40° and 37° 30′, respectively.

It is obvious that the data obtained in a single attempt of this kind are too meager to be the foundation of any theoretical work. Nevertheless, a large number of such observations, where an attempt to maintain a constant elevation is strictly adhered to, would certainly contribute to our knowledge of the motion of air about centers of high and low pressure.

THE PHYSIOLOGY OF THE AVIATOR.[1]

By PROF. YANDELL HENDERSON.

(Abstracted from *Science*, May 9, 1919, pp. 432–441.)

The advantage which accrues to the aviator who is higher than his opponent has led to considerable flying at great altitudes. "Near the end of the war it was quite common for battle planes to ascend to altitudes of 15,000 to 18,000 feet. * * * Along with this development there occurred with increasing frequency among the aviators a condition closely similar to, perhaps identical with, the 'overtraining' or staleness, the physical and nervous impairment of athletes in a football team or college crew." Both conditions seem to be the result of frequently recurring short periods when the body has insufficient oxygen.

"Paul Bert,[2] the brilliant French physiologist, was the first to demonstrate, in 1878, that the effects of lowered barometric pressure or altitude are wholly dependent on the decreased pressure of oxygen."

Thus, these effects are different from those of caisson disease, which results from the formation of bubbles of nitrogen absorbed in the blood and tissues under high pressure, when "the pressure with which the tissues are in equilibrium should have been lowered considerably more than half its absolute amount in a few seconds."[3] Obviously, the aviator can not rise fast enough for this to occur. When the pressure is reduced the dissolved nitrogen diffuses rapidly into the air, and so the internal gas pressure becomes quickly adjusted to the external. "Nevertheless, the idea is still prevalent that hemorrhages occur in low barometric pressures. However, among thousands of people whom I had an opportunity to observe on Pikes Peak during a five weeks stay on the summit, I saw not a single nosebleed." * * * With oxygen breathing apparatus, two experimenters, "Schneider and Whitney, went into the steel chamber (at Mineola) and the air was pumped out of it until the barometer stood at only 180 mm., 23 per cent of the pressure outside—the equivalent of an altitude of 35,000 feet."

"To sum up all that has been said thus far, the influence of low barometric pressure is not mechanical but chemical. Life is often compared to a flame; but there are marked differences, depending upon the peculiar affinity of the blood for oxygen. A man may breathe quite comfortably in an atmosphere in which a candle is extinguished. The candle will burn with only slightly diminished brightness at an altitude at which a man collapses. The candle is affected by the proportions of oxygen and nitrogen. The living organism depends solely upon the absolute amount of oxygen—its so-called partial pressure."

[1] Presented before Harvey Society, Mar. 22, 1919.
[2] "*La Pression Barométrique.*" Paris, 1878.
[3] Further details are given by Prof. Henderson and still more by J. S. Haldane, Nature, Vol. 96, pp. 173–174.—C. F. B.

The body may become acclimatized to a smaller amount of oxygen, but the acclimatization is generally too slow to be of much help to the aviator. "As we observed it in ourselves during our stay on Pikes' Peak acclimatization consists in three chief alterations: (1) Increased number of red corpuscles in the blood; (2) some change in the lungs or blood (Haldane considers it the secretion of oxygen inward by the pulmonary tissue), which aids the absorption of oxygen, and (3) a lowering of the CO_2 in the lungs is bound up with increased volume of breathing [and decreased alkaline reserve in the blood]."[4]

On Pikes Peak we saw that persons whose breathing under the stimulant of oxygen deficiency increased quickly to the amount normal for the altitude suffered correspondingly little, while those whose respiratory center was relatively insensitive to this influence suffered severely." It seems now firmly established that during any brief period of time, and under conditions to which the individual is accustomed, that the factor controlling the volume of air breathed is the amount of CO_2 produced in the tissues of the body through its influence on the C_H of the blood. "The oxygen tension of the air is the influence which determines just how sensitive the respiratory center is to excitement by CO_2.[5] The quickness with which the respiratory center changes with change in oxygen thus becomes an important criterion of fitness in aviator candidates. Fifteen to twenty per cent of all the men who pass an ordinary medical examination are unfit to ascend to the altitudes now required of every military aviator. On the other hand, these tests pick out a small group of 5 to 10 per cent, who, without apparent immediate physical deterioration, withstand oxygen deficiency corresponding to altitudes of 20,000 feet or more." It is particularly interesting to note that when the rebreathing test is pushed beyond the limit that the man can endure, be it the equivalent of only 10,000 or 25,000 feet, two different physiological types with all gradations between them are revealed. The fainting type collapses from circulatory failure and requires an hour or two to recover. Often the heart appears distinctly dilated. The other and better type, on the contrary, goes to the equivalent of a tremendous altitude on the rebreathing apparatus and loses consciousness, becoming glassy-eyed and more or less rigid, but without fainting. When normal air is administered such men quickly recover.—*C. F. B.*

The heart action of an aviator during flight has been summarized by Dr. G. Ferry (*Sci. Am.*, Apr. 29, 1916, p. 445) as based on a number of flights. His conclusions are: The pulse becomes more and more rapid from the ground up to a height of 750 meters; from this height up to 1,250 meters it still augments, but less rapidly; and above this height it again accelerates more rapidly. The period of slower acceleration seems to be explained by the fact that between 750 and 1,250 meters the air is usually calmer than at lower altitudes, and the wind more regular. Above this height the cold becomes a greater factor in acceleration. Each time a gust strikes the airplane the pulse accelerates. During a flight at a particular altitude the pulse remains constant. When descent begins there is again for a very short period a quickening of the pulse, due, it is thought, to the thrill of excitement experienced when the engine is shut off. After this the frequency falls in a regular manner during a slow descent. Each event in the descent causes an acceleration, short but definite. The pulse at the end of the flight is always more rapid than at the beginning.—*C. F. B.*

Henry Woodhouse in "High Altitude Flying in Exploration" (*Geogr. Rev.*, March, 1919, pp. 156-158) calls attention to the following notes from the account of a balloon flight made by Jacques Schneider, Maurice Bienaime, and Albert Senouique in May, 1913. Dynamometer tests were made at 10,081 meters: For Mr. Senouique on earth it was 105, in the air 110; for Mr. Bienaime on earth it was 140, in the air 155. At this altitude one's heart is beating about 110 pulsations per minute, producing a blood pressure equal to about 25 centimeters of mercury with the exterior pressure 210 mm. and the interior pressure 250 mm. The strain produced in the tissue of the circulation system is powerful enough to cause death.[6]—*C. L. M.*

THE COMPOSITION OF THE ATMOSPHERE.

By Dr. K. SCHÜTT.

[Reprinted from the Aeronautical Journal, London, November, 1918, p. 382.]

In the course of his paper Dr. K. Schütt refers to an investigation by A. Wigand, who took samples of air at various heights from 1,500 to 9,000 meters and established an increase in the proportion of hydrogen with increase of height and a decrease in the proportion of carbon dioxide. On the basis of this investigation, the following figures are given for the percentage of hydrogen in the atmosphere at 0.20, 50, and 100 km., 0.01, 0.05, 3.72 and 97.84. The subject discussed in greatest detail is the nature of the layer which acts as an electrical conductor and guides "wireless" waves round the globe. A proposal to determine the height of this layer by projecting electric waves obliquely upward and finding where they return to earth is mentioned.—*Bulletin Aero-Club Suisse*," *August, 1918.*

[4] A fourth effect mentioned by Dr. A. M. Kellas, *Geogr. Journ.*, *January, 1917*, in discussing the possibility of climbing Mt. Everest, is the more rapid circulation of the blood stream during exercise.—C. F. B.

[5] The aeronaut or aviator who may doze at high altitudes may experience the difficulties mentioned by Mrs. F. B. Workman, relative to sleeping at 21,300 feet in the Himalayas (*Independent, June 5, 1916, pp. 380-382*): "As soon as we began to doze and the respiratory movements diminished in force and frequency, the tissues did not get enough oxygen, and we would start up, gasping for breath."—C. F. B.

[6] A discussion of the cause and best means of fighting "flying sickness" is given by Lieut. Col. Martin Flack in "Flying Sickness," reprinted from *Aeronautics, in Sci. Am. Supp.*, Apr. 26, 1919, p. 262.—C. F. B.